Texas Ionosonde

Restoring Ionosonde Observations to the Texas Region

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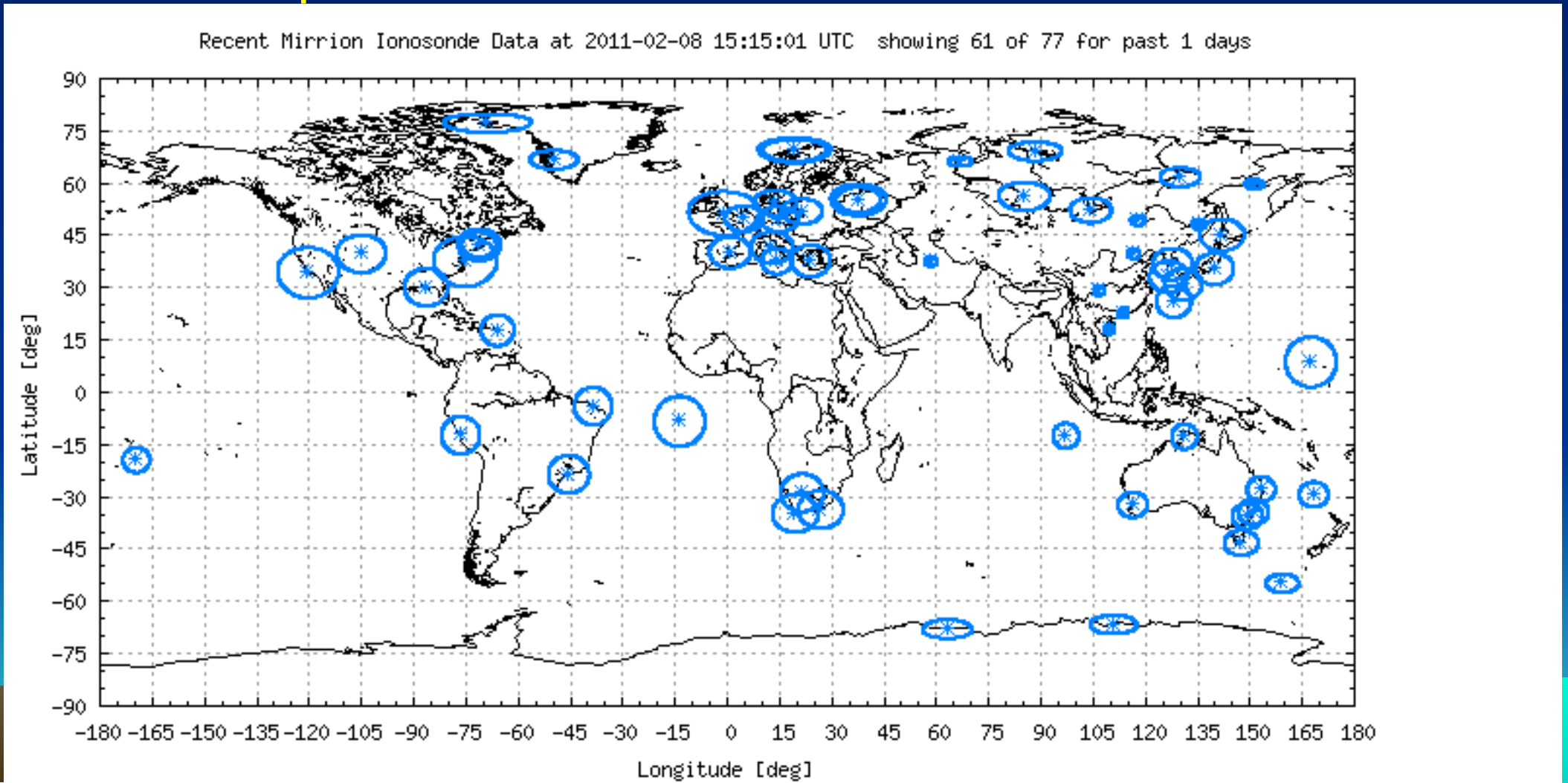
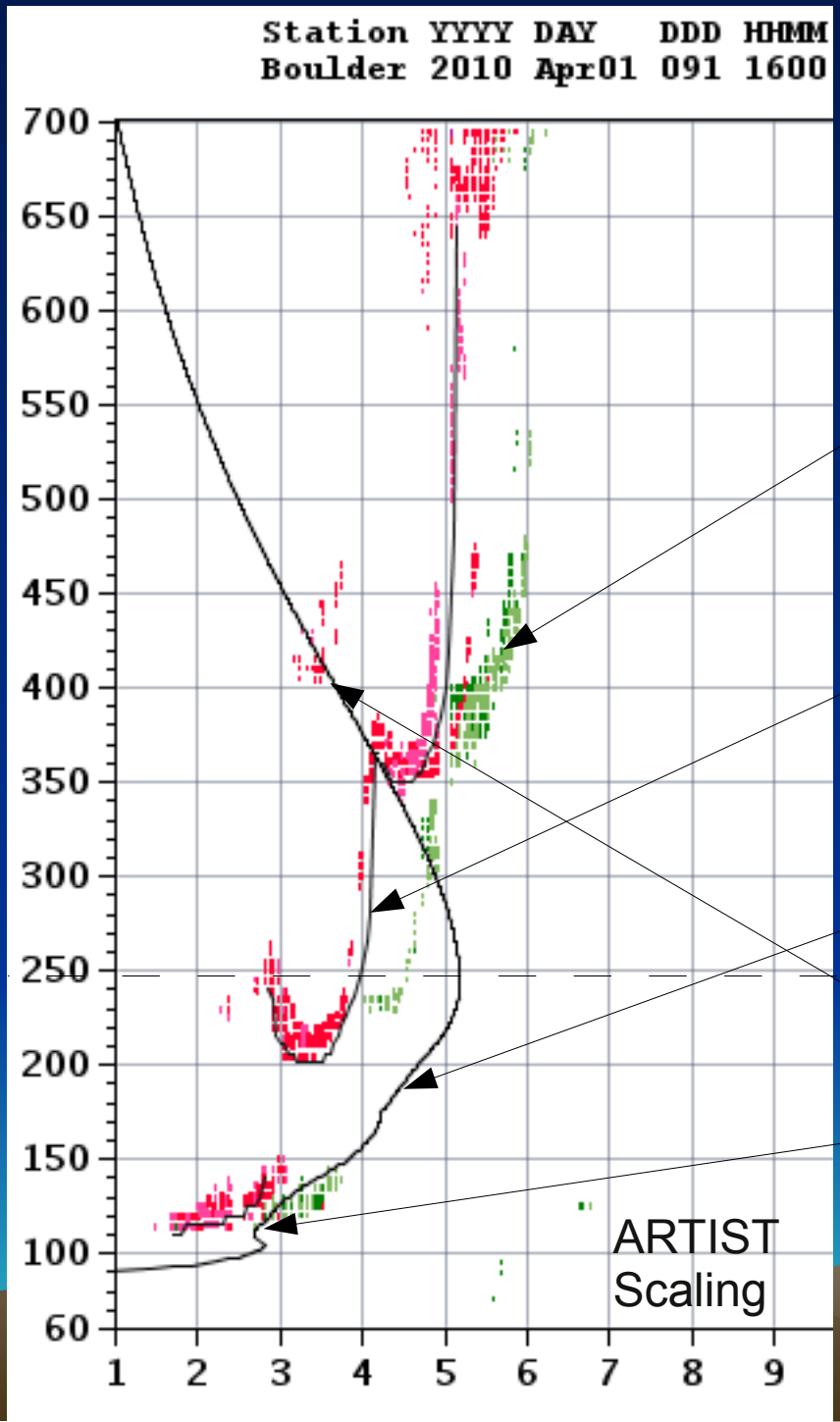
In Cooperation with:
National Oceanic and Atmospheric Administration
National Geophysical Data Center
Solar and Terrestrial Physics Division

Objective

- Fill the “Texas Gap”
- Created by removal of DISS at Dyess AFB
    - April 2009



What is an Ionosonde and what does it do?



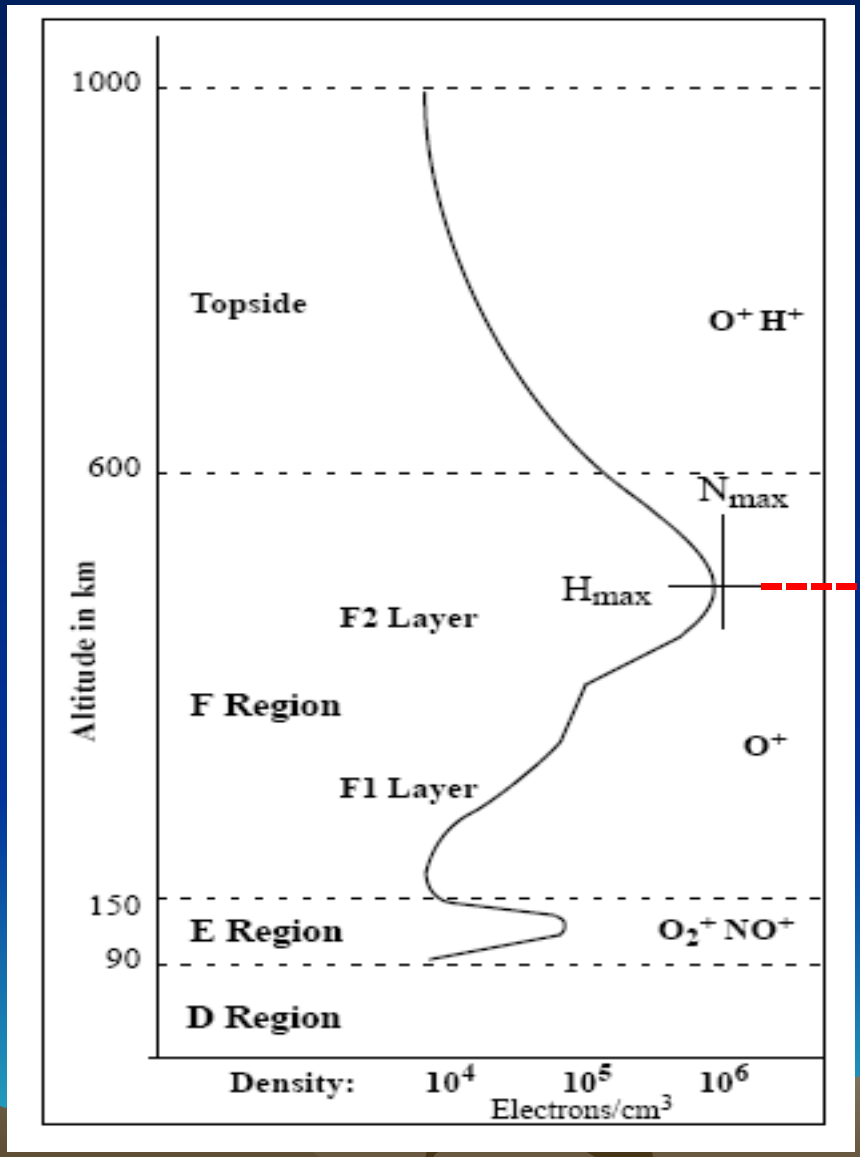
- MF-HF Radar (1-20 MHz)
- A acre or ten of antennas
- Measures ionosphere reflection height at a precise density (sounding frequency)
- Feature recognition software needed in an often complex image
- Inversion process required to obtain bottom-side electron density profile
- Valleys and Topside are modeled or extrapolated

Ionosphere Vertical Electron Density Profile

The F2 region varies by 3-5X diurnally, highest just after noon, lowest before dawn.

The F1 region and E region dissipate at night.

The D region is present only during daytime and in times of high activity.



Ionosondes Measure Up To H_{max}

Requirements

- Real Time ionosonde data
- Electron Density Profiles every 15 minutes
  - Global Ionospheric Specification and Forecast
  - AFWA GAIM
- Texas Army MARS HF Propagation
- US National Space Weather Program objectives
- Global ionosonde data users
- Ionosphere Research
- Global Ionosphere Climate Record

Constraints

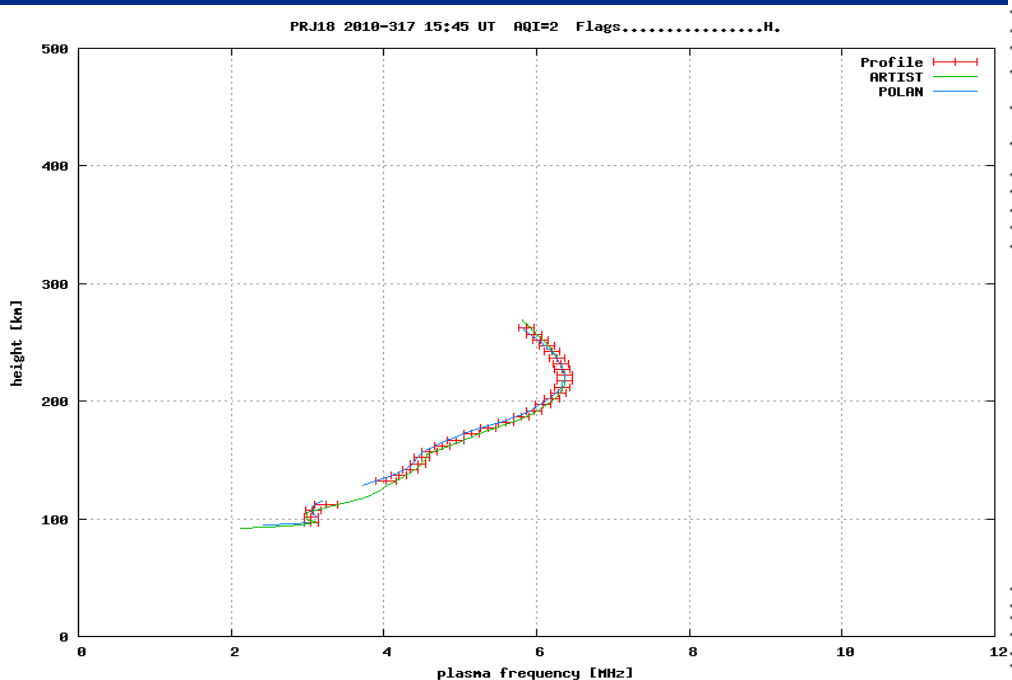
- Equipment:
  - Refurbished USAF DISS
  - Set by Real Time EDP Requirements
- Schedule
  - FY2011
- Budget
  - FY2010 fallout funds
- Location
  - “Southern Texas”

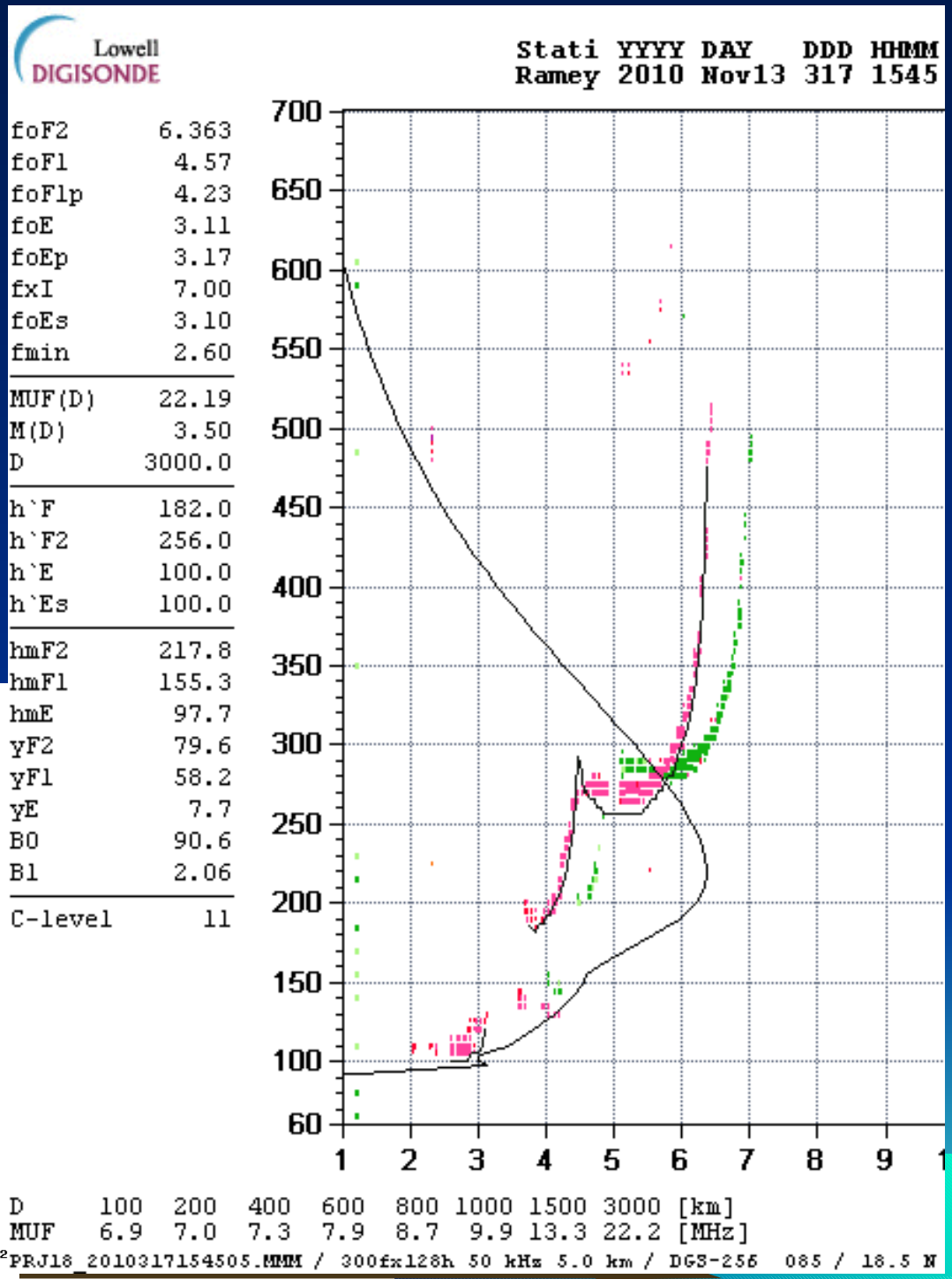
Proposed Approach

- Meet primary operational requirements
  - Digisonde → ARTIST
  - Distribution through NOAA
- Prepare for a near-term VIPIR upgrade
- Refurbished D256v
  - Solid state transmitter
  - VIPIR receive antenna array
  - Medium size iDelta transmit antenna

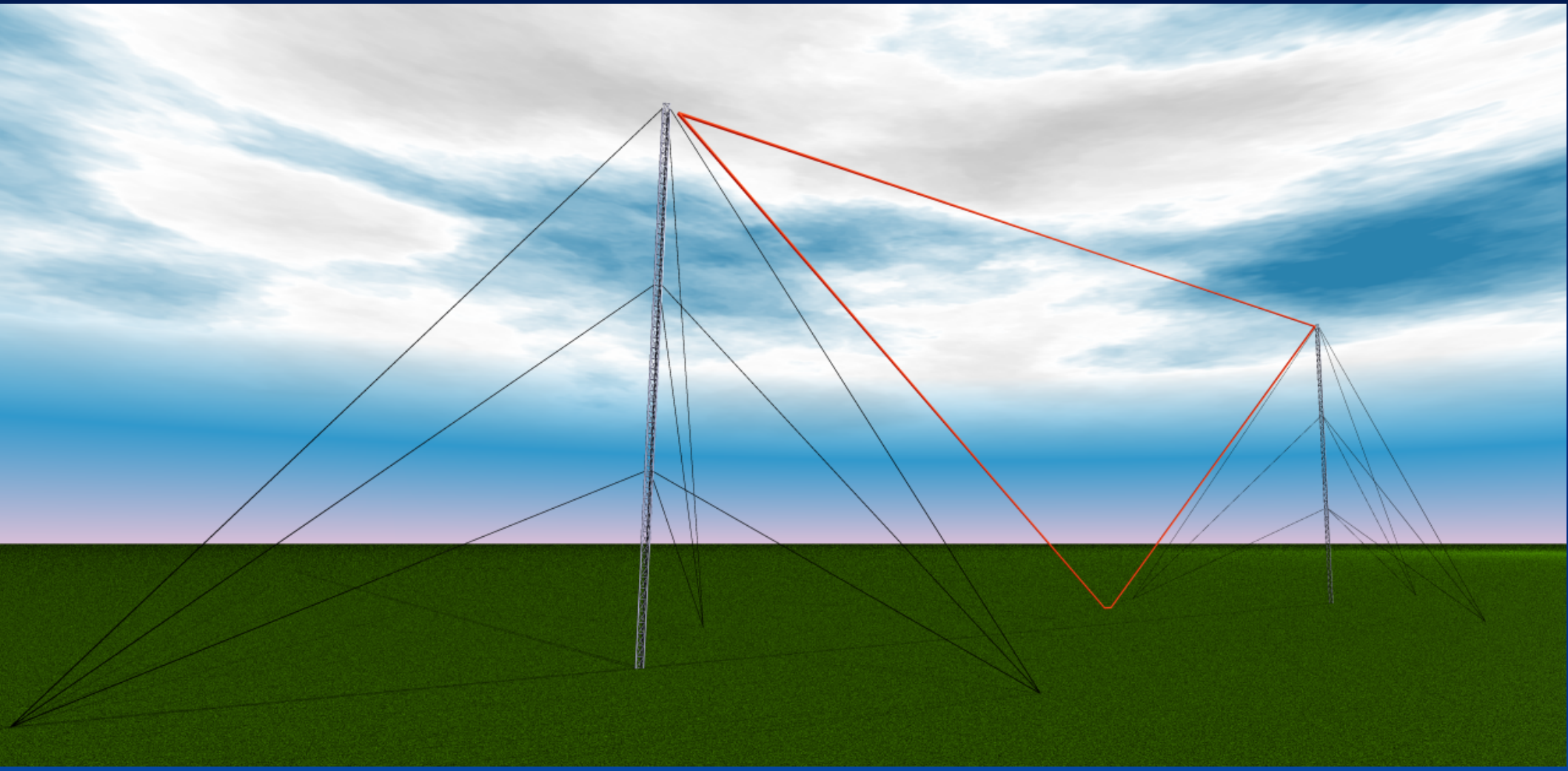
Digisonde Data

- 15 minute cadence
- Real Time Data
- Digital Ionograms
- Scaled values
- Density Profiles
- Quality flags
- Error Bars





Inverted Delta Transmit Antenna

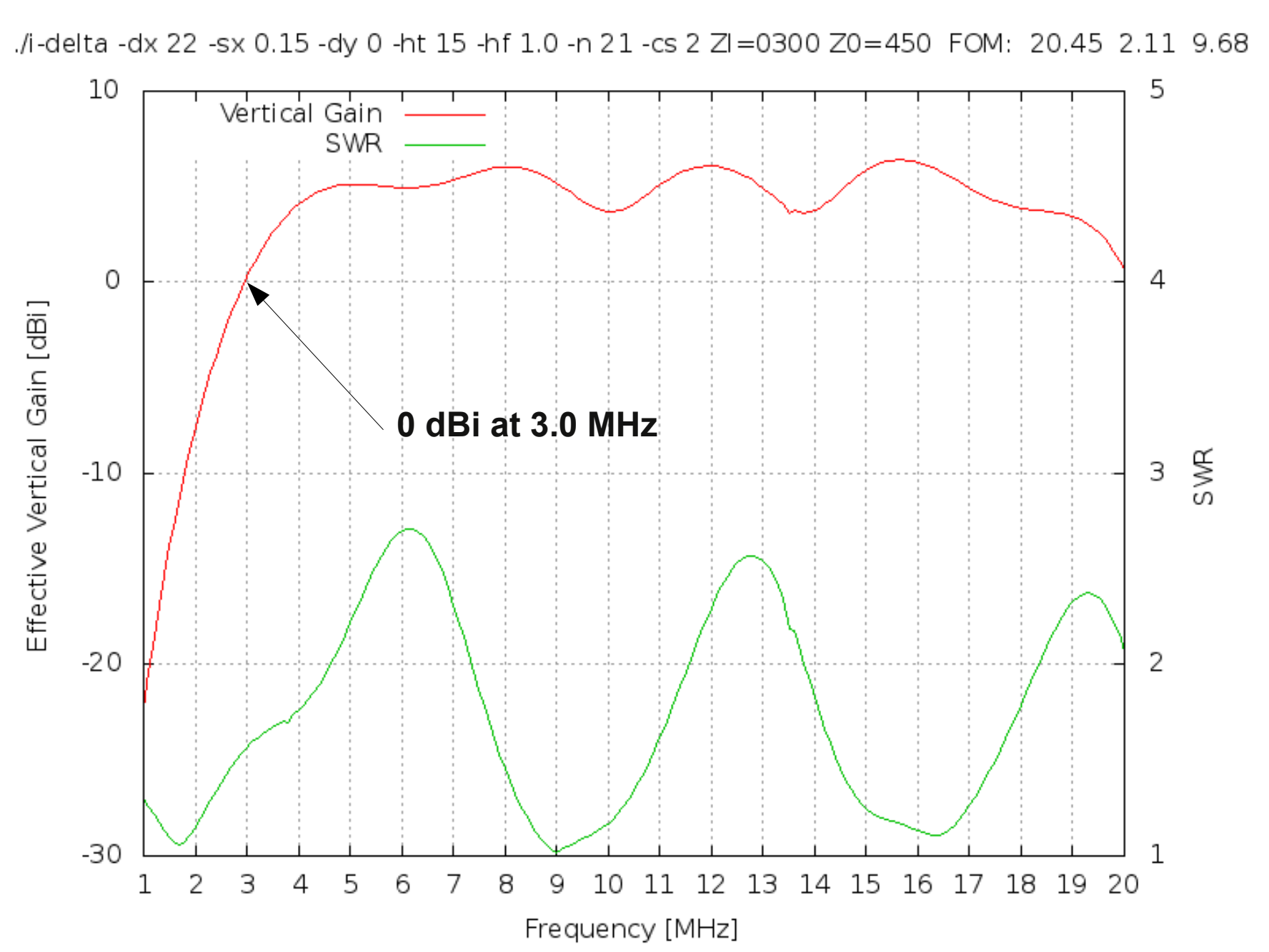


+10 dB better than a single tower delta for +3 dB cost
Traveling wave antenna
Two guyed towers
Bottom feed point
Tradeoff: Smaller size performs better at high frequency but worse at low

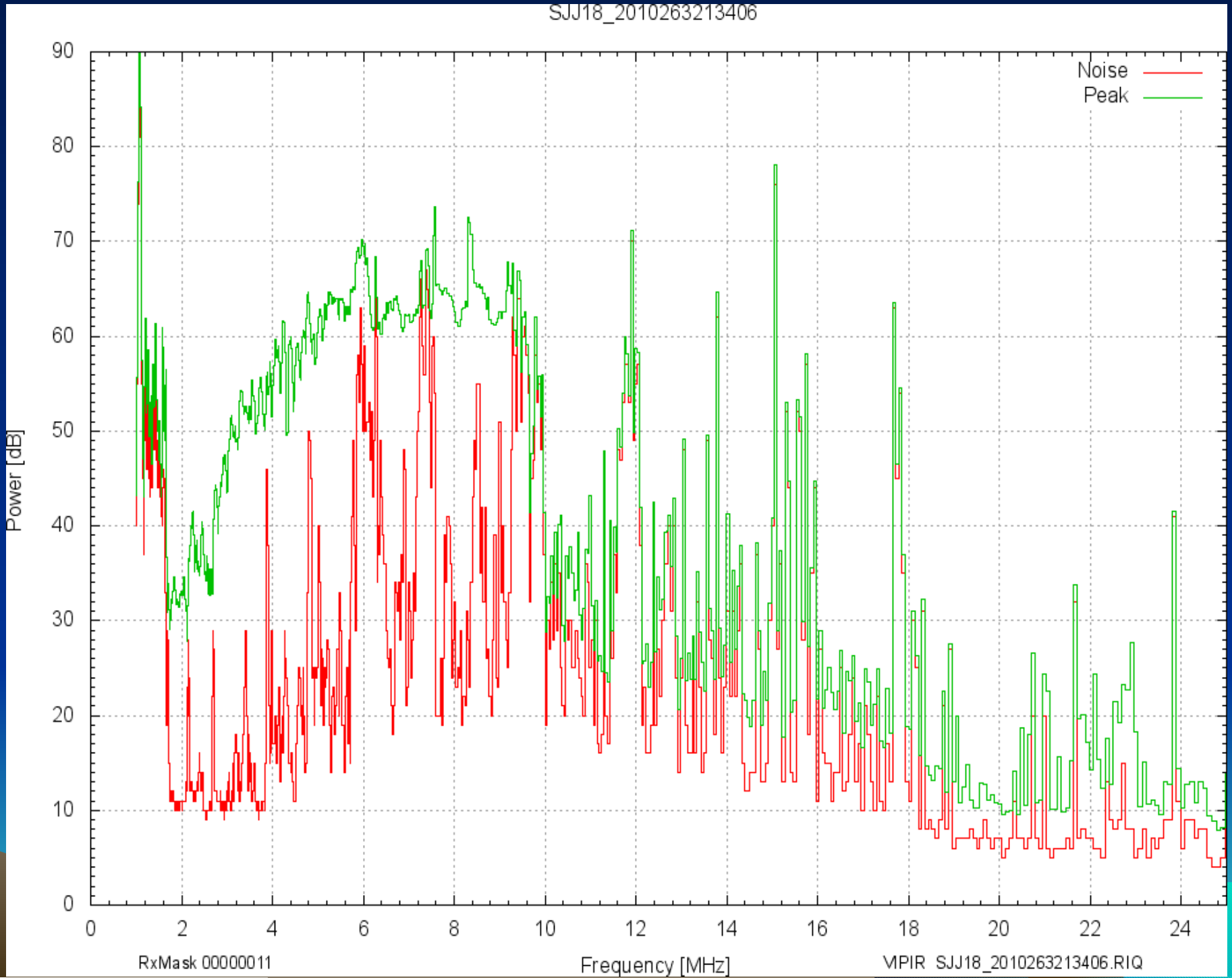
Inverted Delta Transmit Antenna

San Juan Observatory
“Small” : 15m tall x 45m long
Minimum Recommended Size

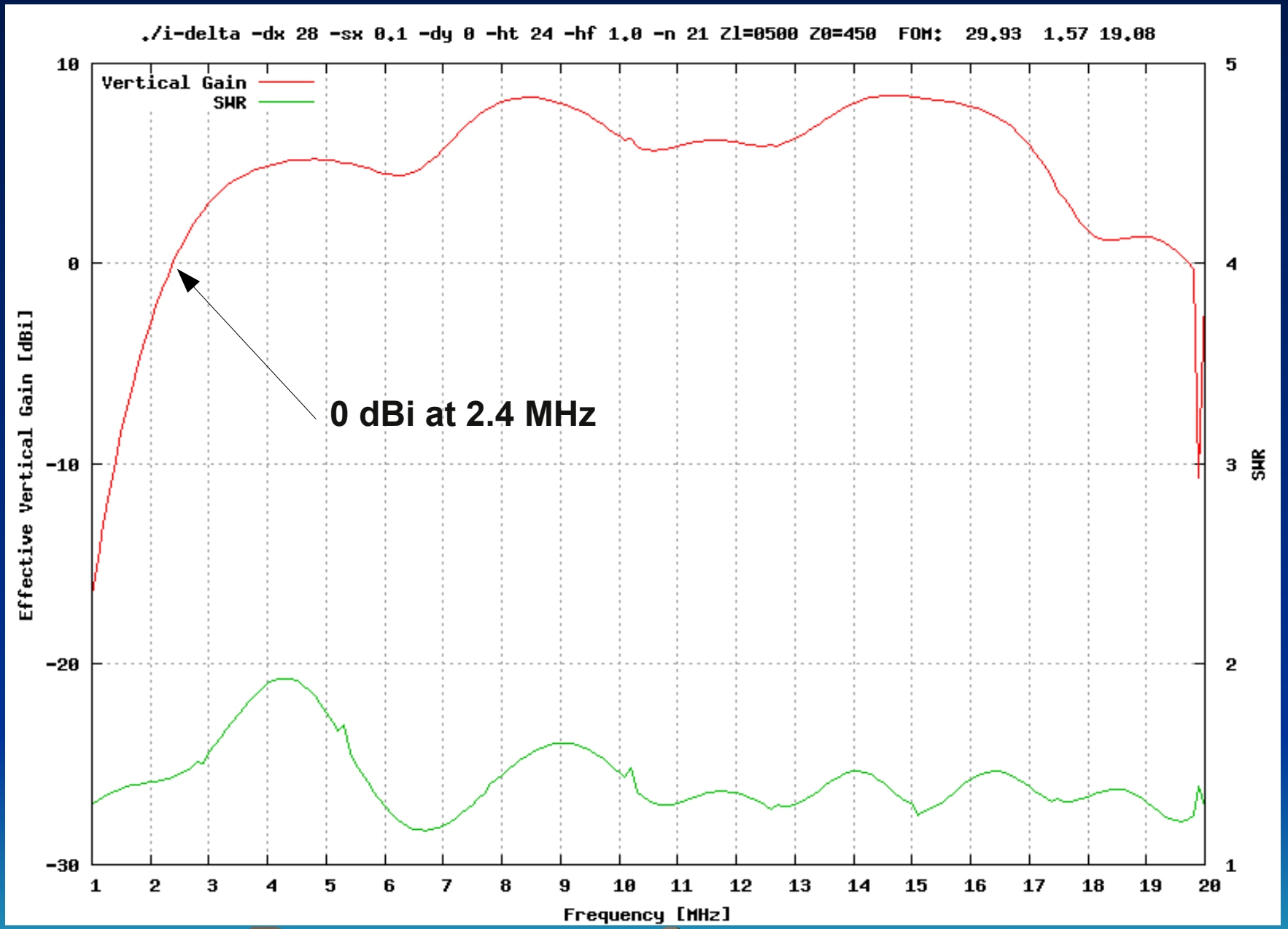
Transmit Antenna Modeled Performance



SJJ18 Signal and Noise Spectrum

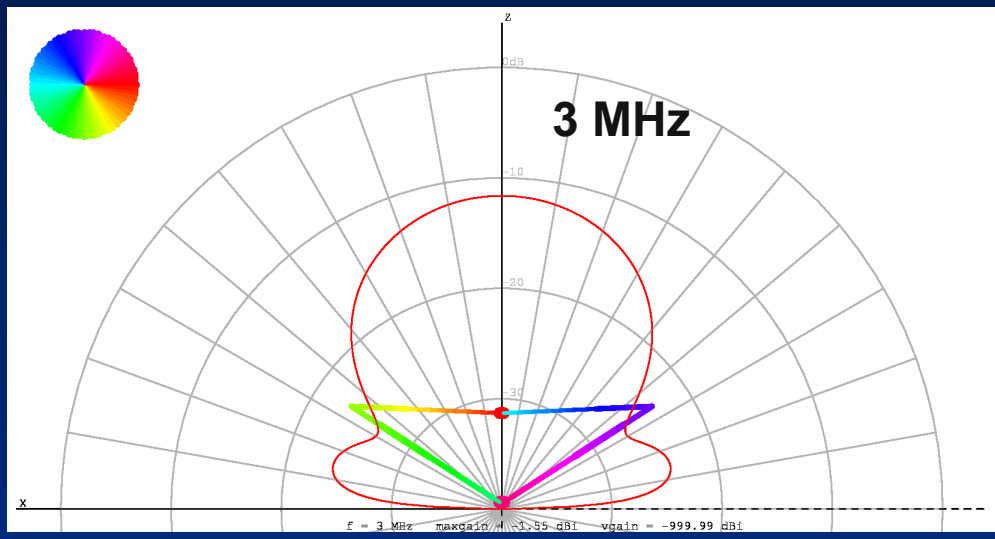


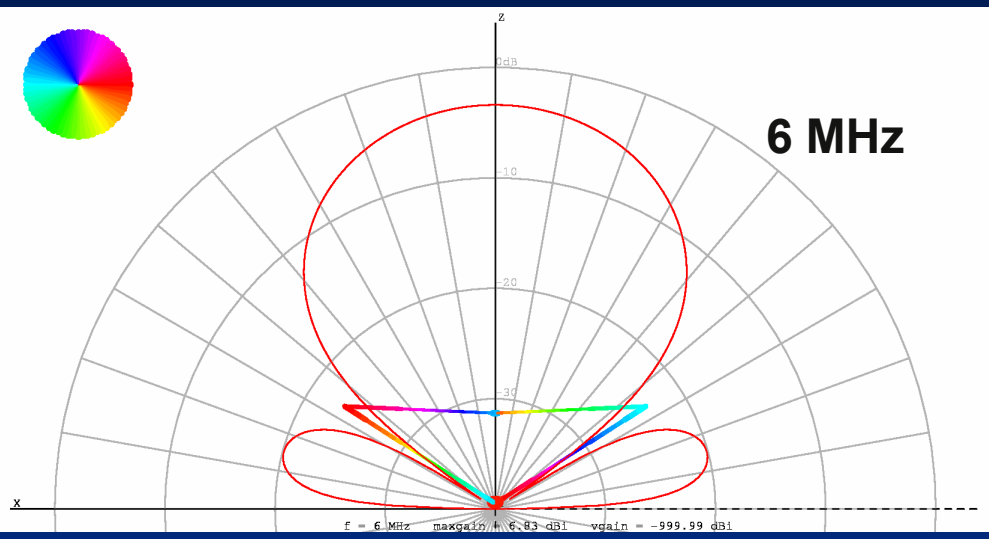
Medium iDelta

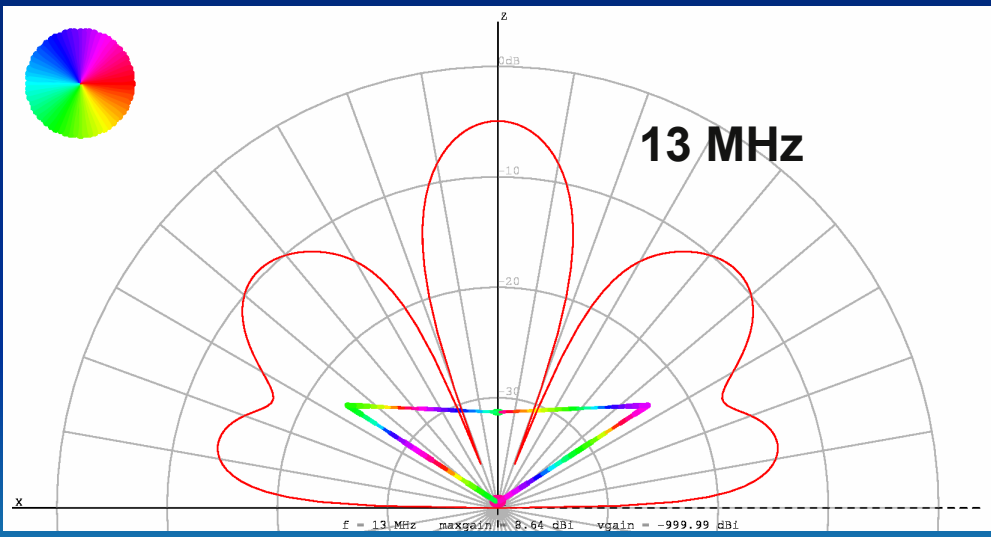


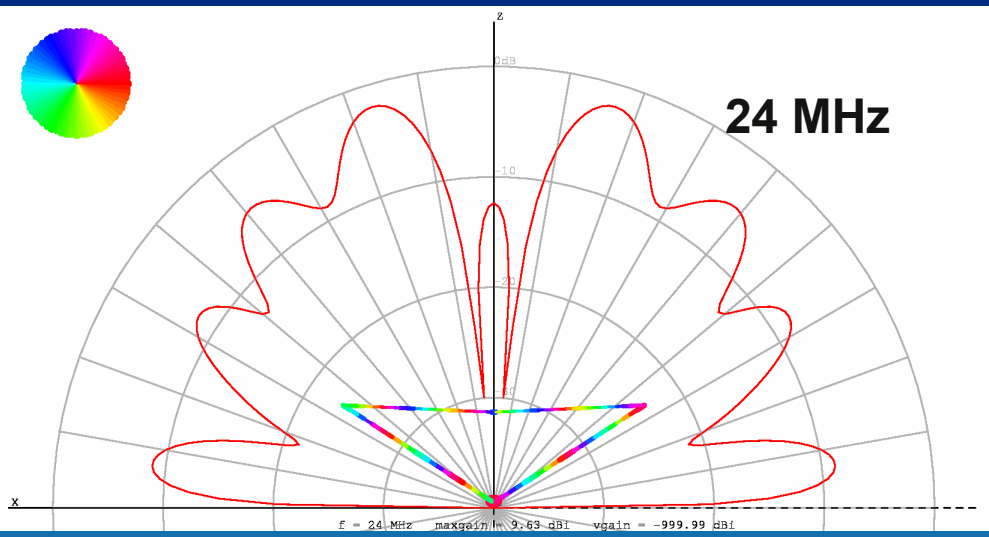
Nominal Texas iDelta
“Medium” : 24m tall x 56m long
Near Maximum Recommended Size

Puerto Rico iDelta Radiation Patterns





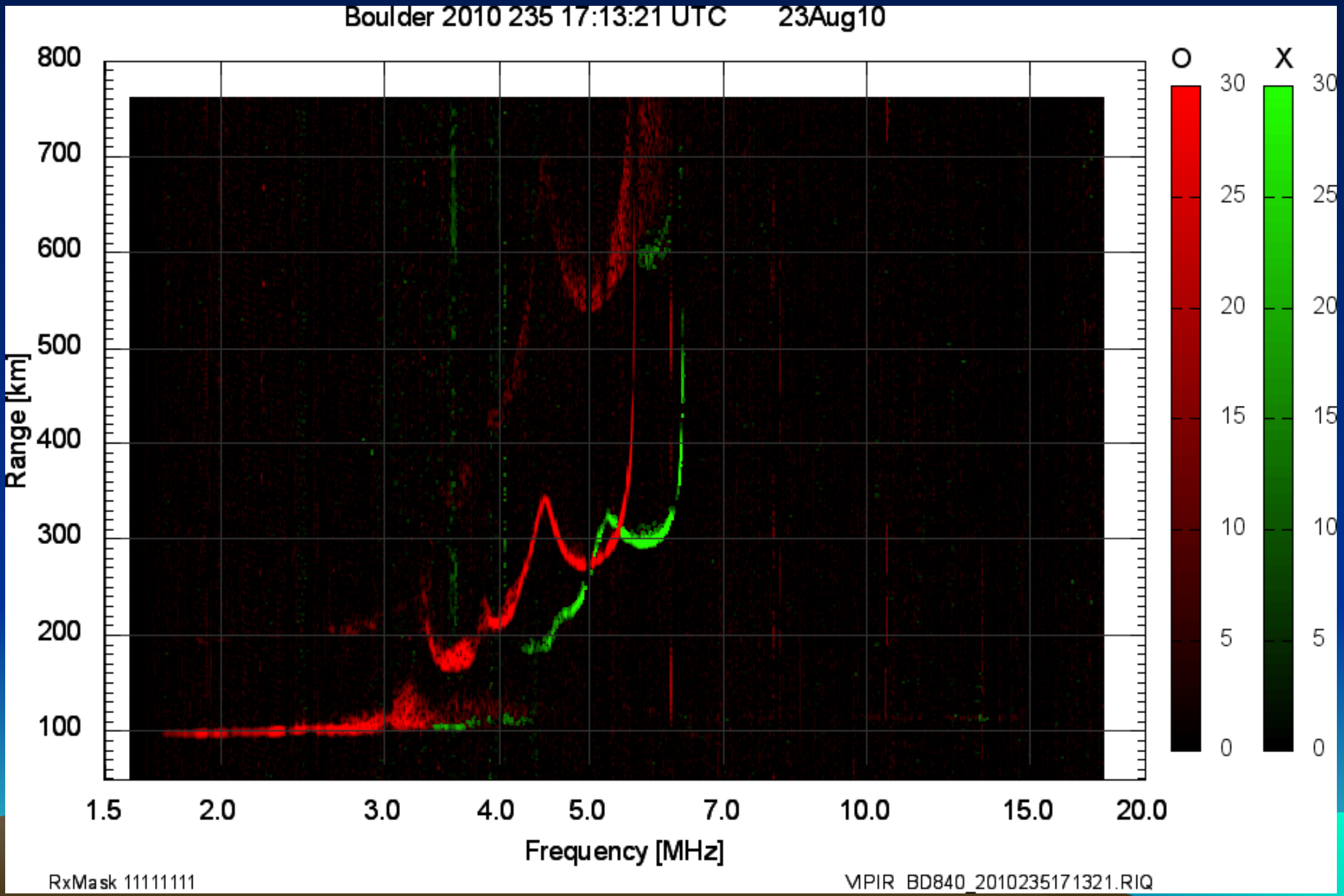




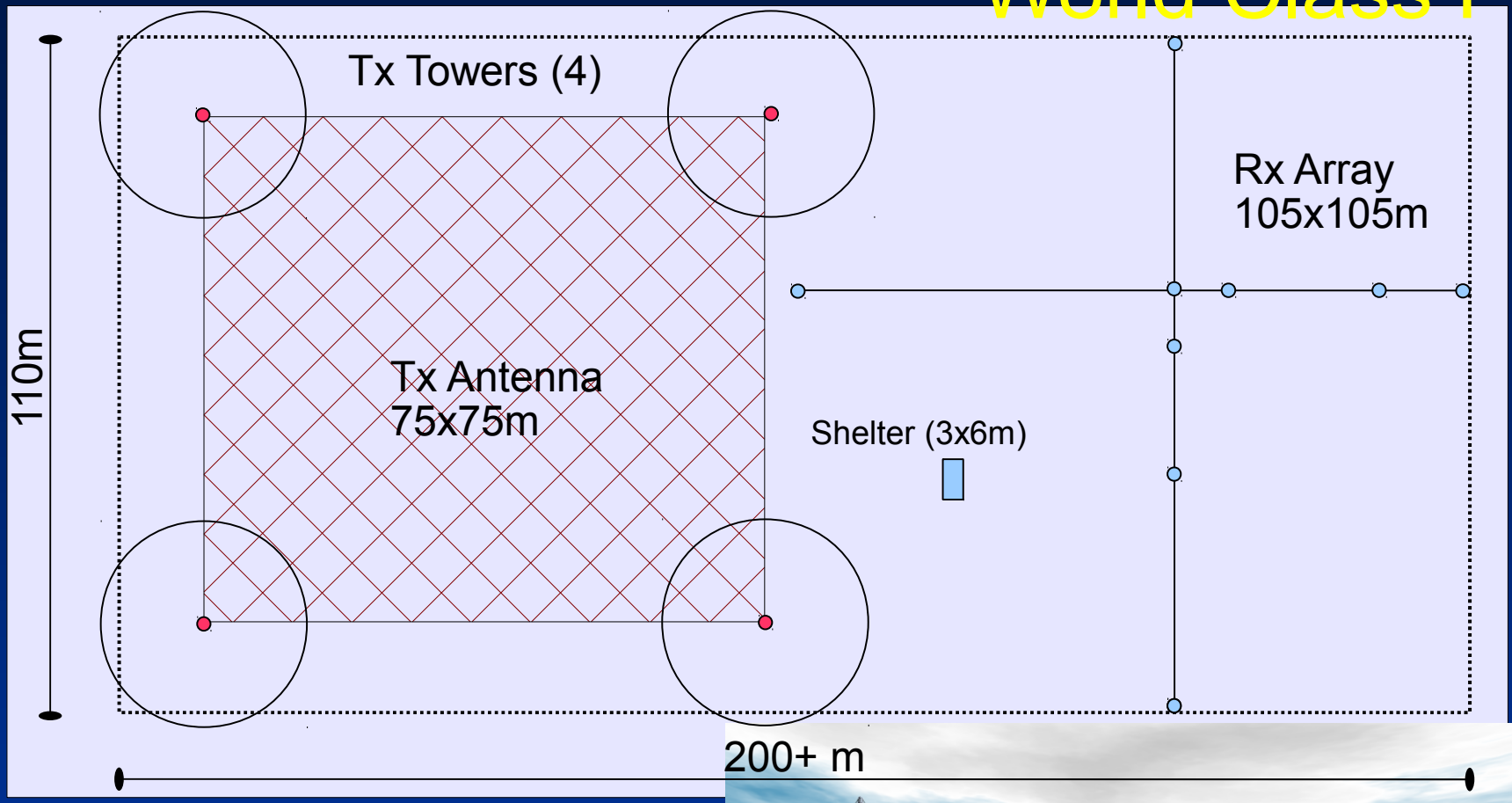
Looking Forward

- While this effort cannot afford to support a world class research ionosonde, there are several low-cost steps we can take now to reduce the cost of a future upgrade
  - Anticipate upgrade to dual VIPIR-Digisonde site
    - Boulder, Wallops, Puerto Rico
  - Plan for a 4 tower Log Periodic Antenna
    - Higher gain, smoother patterns
    - Another constraint in the 2-tower design
  - Use dipole receive antennas
    - Improves performance of the Digisonde

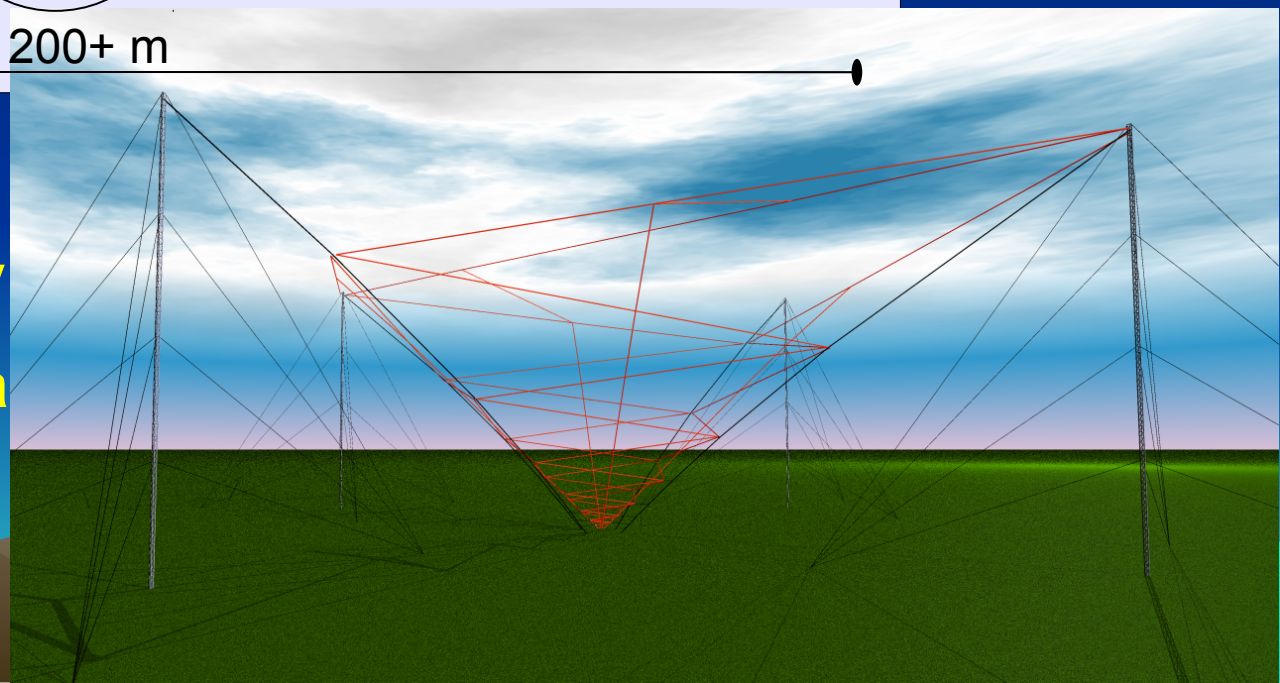
VIPIR Daytime Ionogram



World Class Field Site

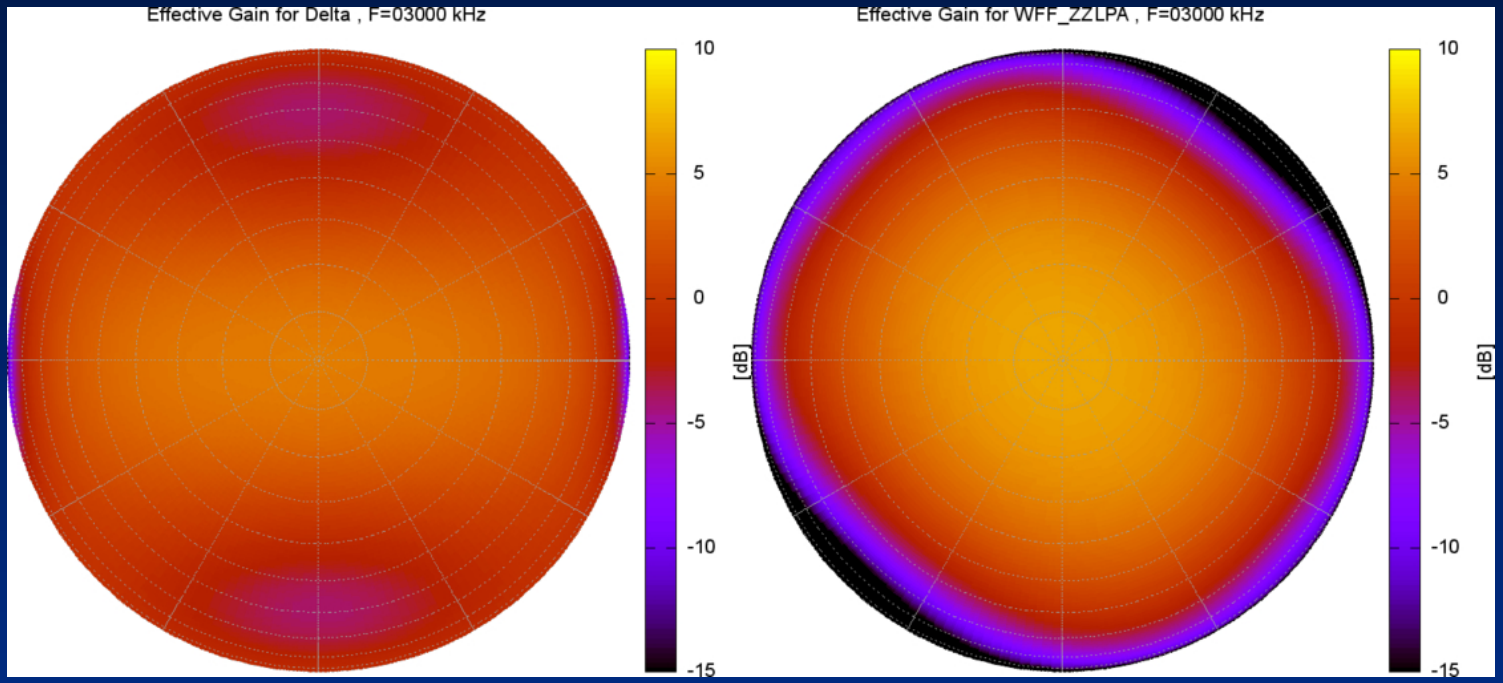


- 8 channel HF radar
- 8 or 10 element Rx array
- Log-periodic Tx antenna
- 35m steel towers (4)
- 5 to 10 acre footprint



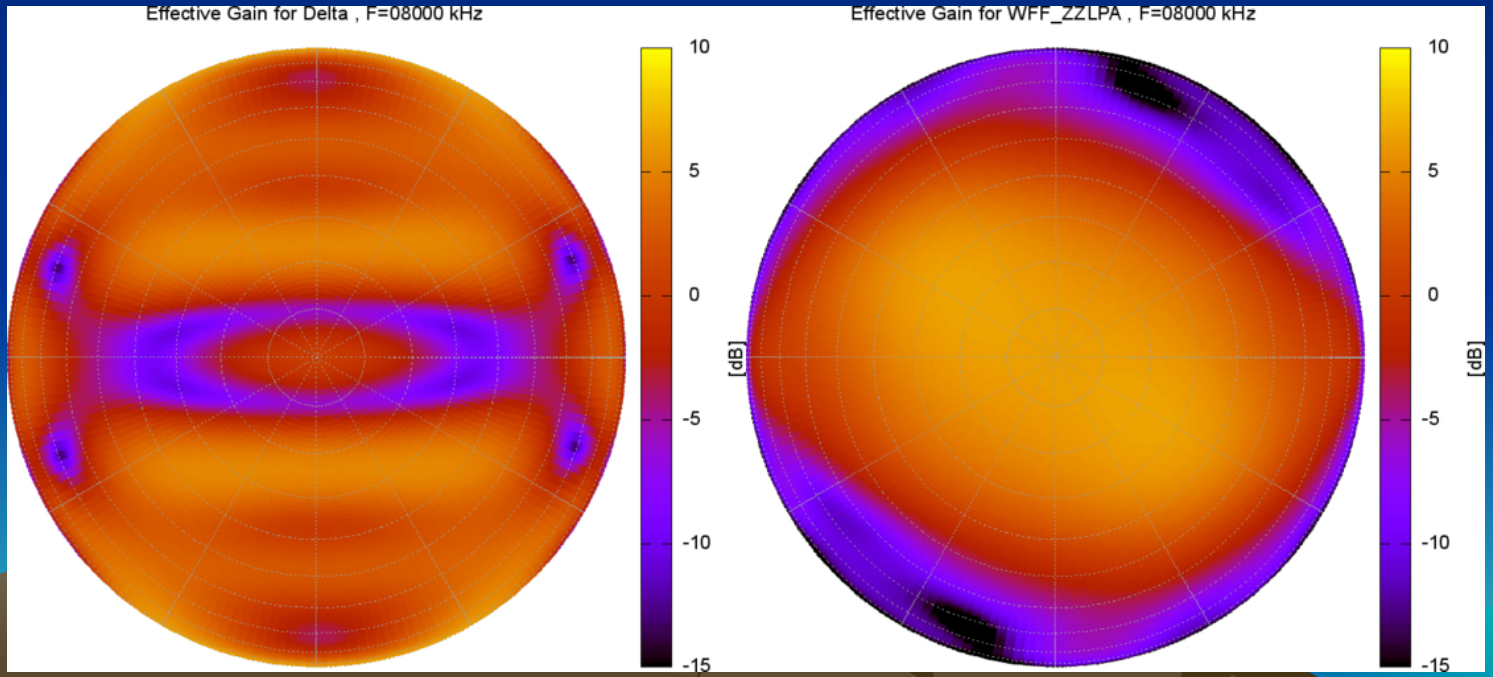
Delta vs LPA

Delta 3 MHz



LPA 3 MHz

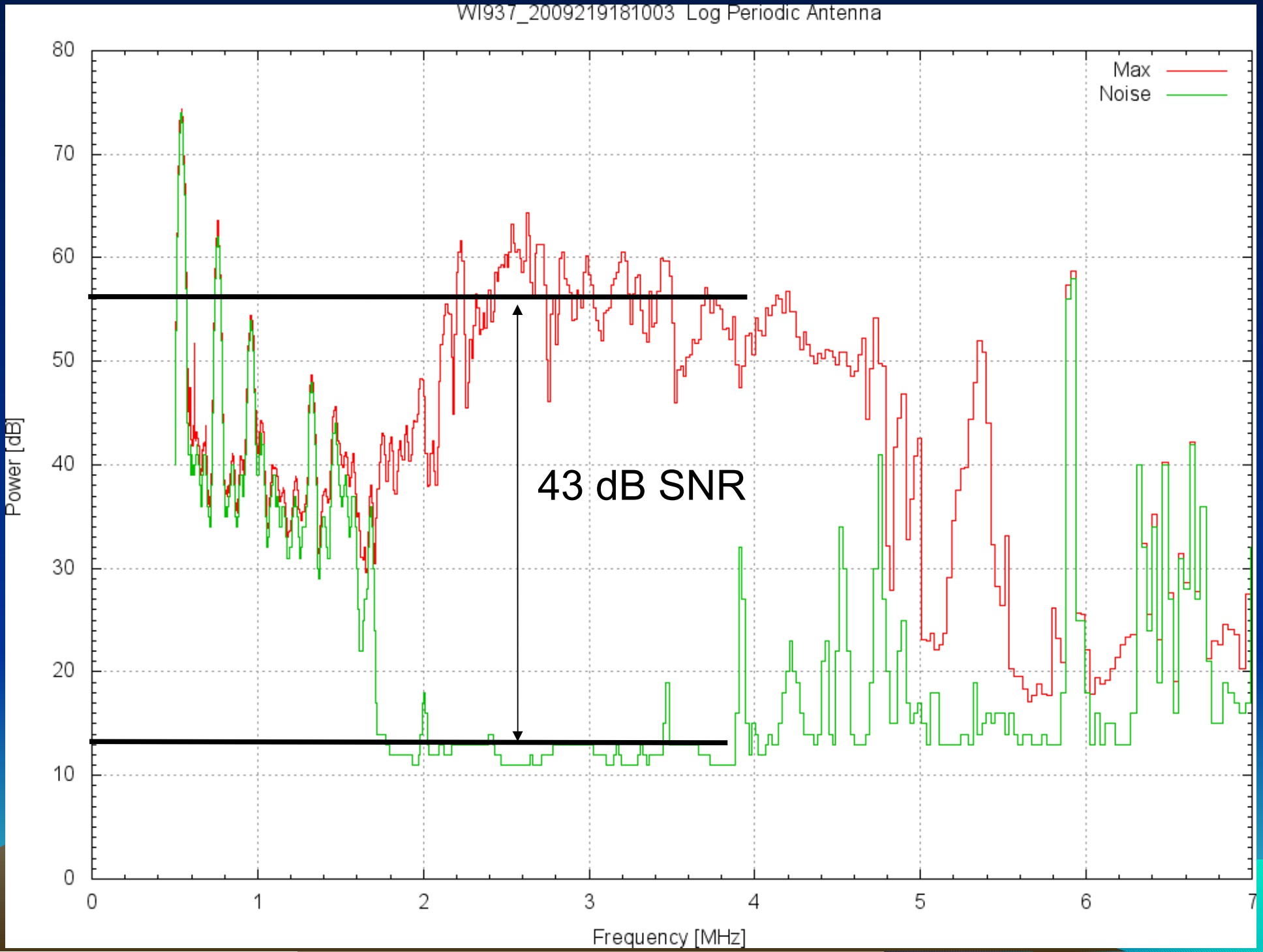
Delta 8 MHz



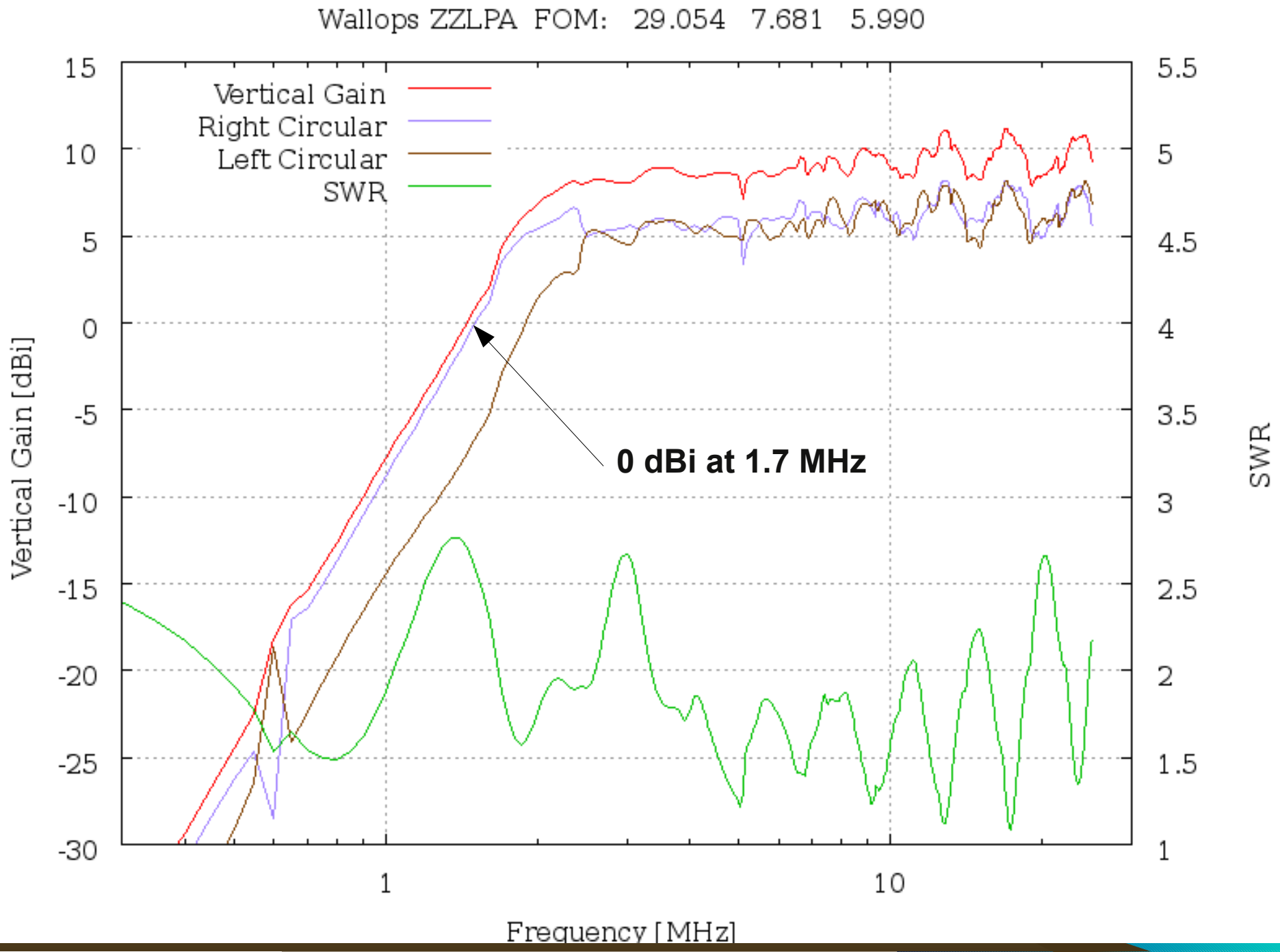
LPA 3MHz

NOTE: The delta in this design example is especially large for low frequency performance

Wallops Log Periodic Tx Antenna Signal and Noise



Log Periodic Antenna Performance



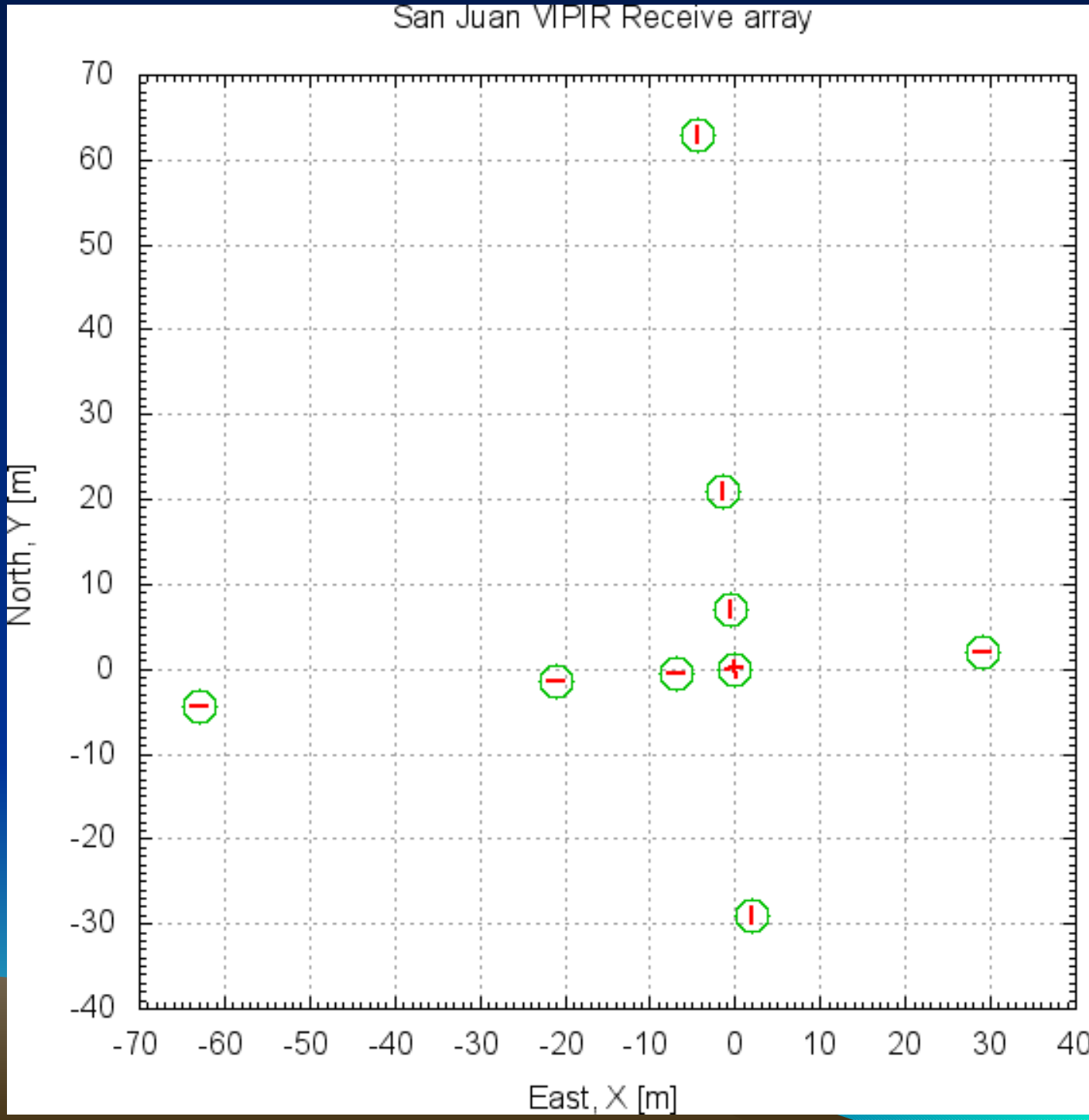
Puerto Rico Receive Antennas

VIPIR

Antennas at locations
-9 -3 -1 0 +4
Gives separations of
1 2 3 4 5 6 7 8 9 13
Units of 7m in PR

Why:
Super-Resolution

For TX:
Locations
-3 -1 0 +4
Separations
1 2 3 4 5 7
Separation ~10m



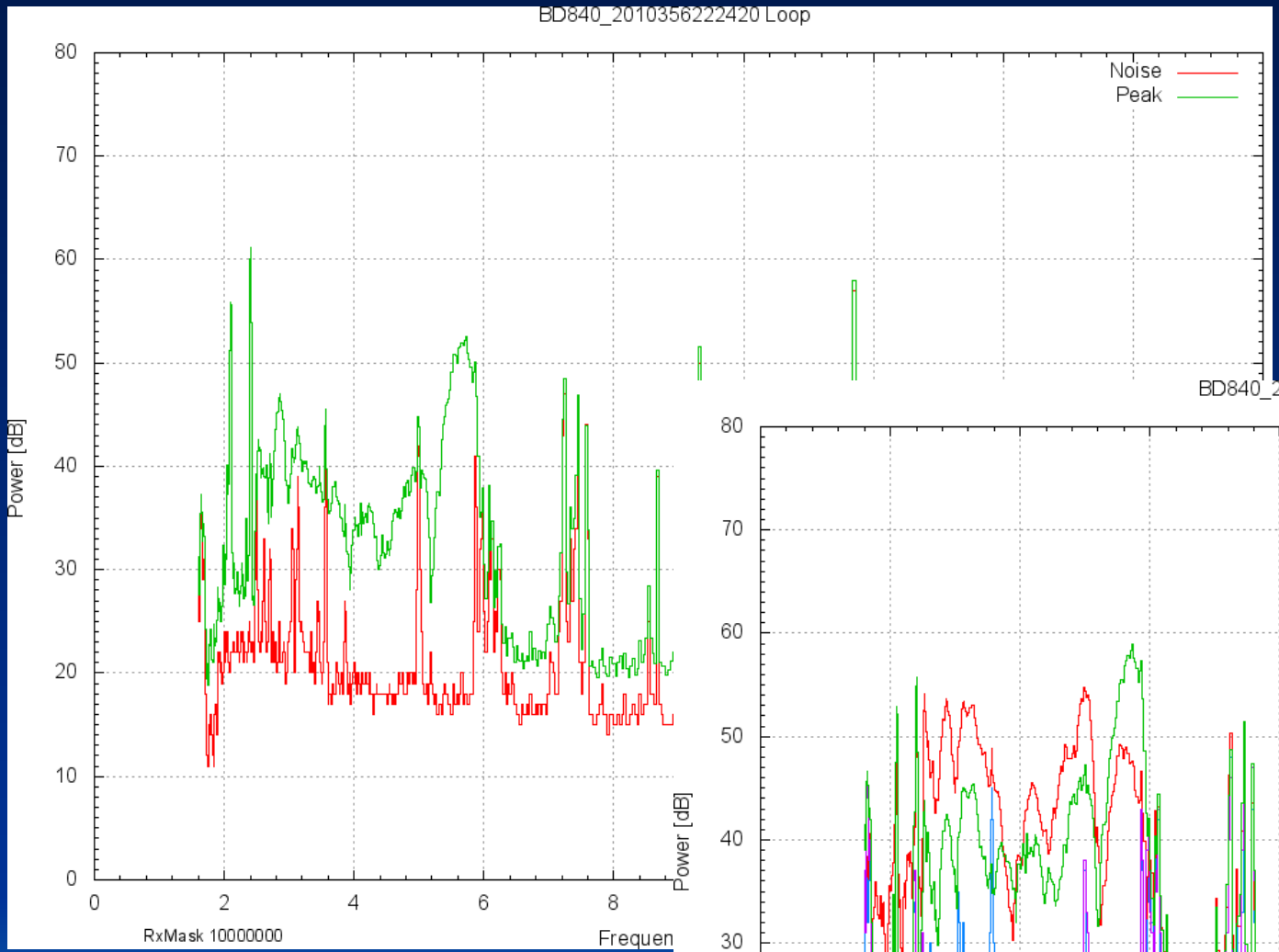
Polarization

- Ordinary and eXtraordinary polarizations are circular and of opposite rotation
    - Except very near the magnetic equator, where they are linear
- Two orthogonal, linearly polarized antennas can form a circularly polarized antenna with a ± 90º phase shift and summation
    - Digisondes do this in hardware at the antenna
    - VIPIR does this in the analysis software

San Juan, Puerto Rico

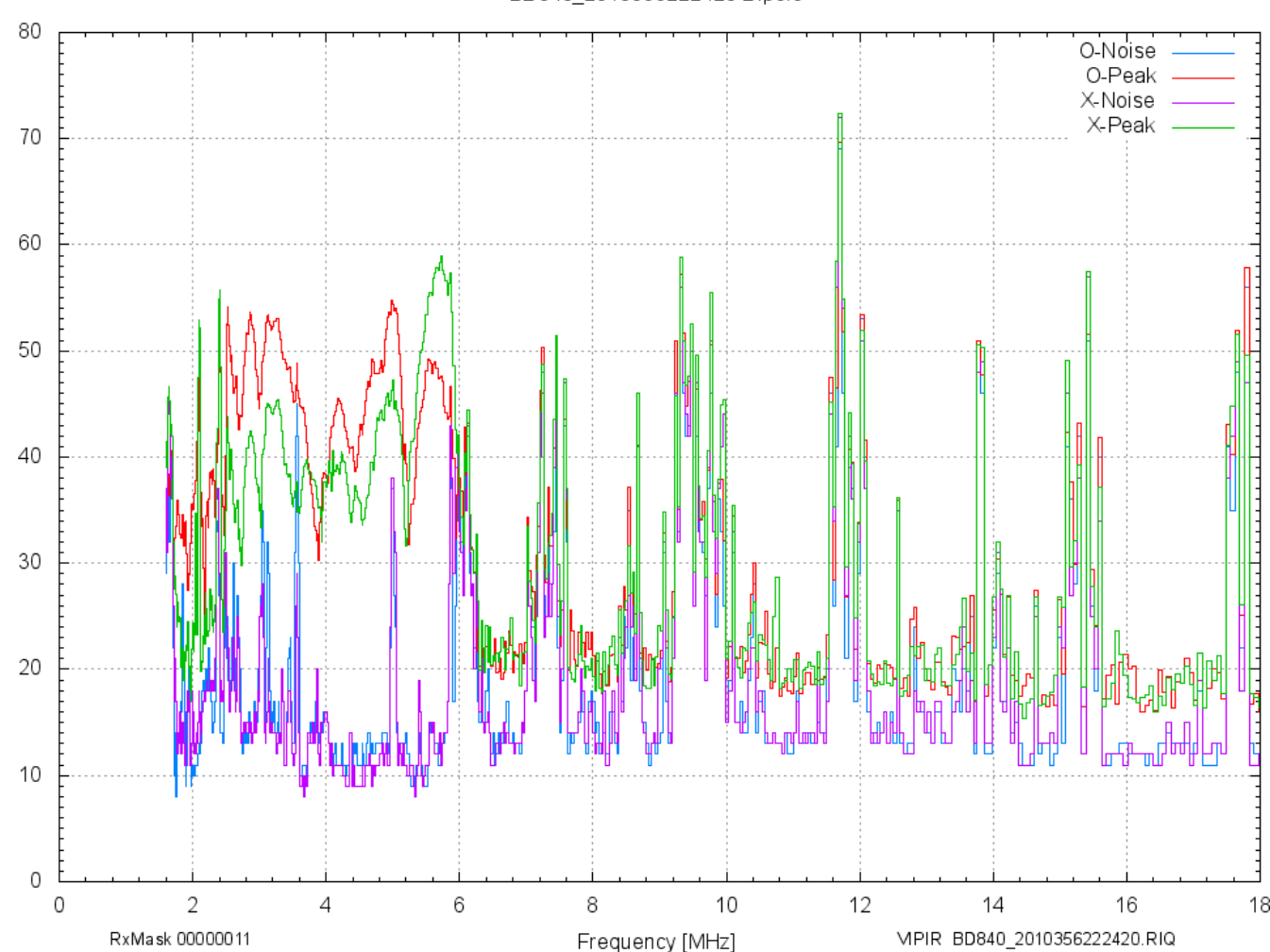
Receive Loops vs Dipoles

Loop and Dipole Rx Antennas



Loop: 15-20 dB SNR

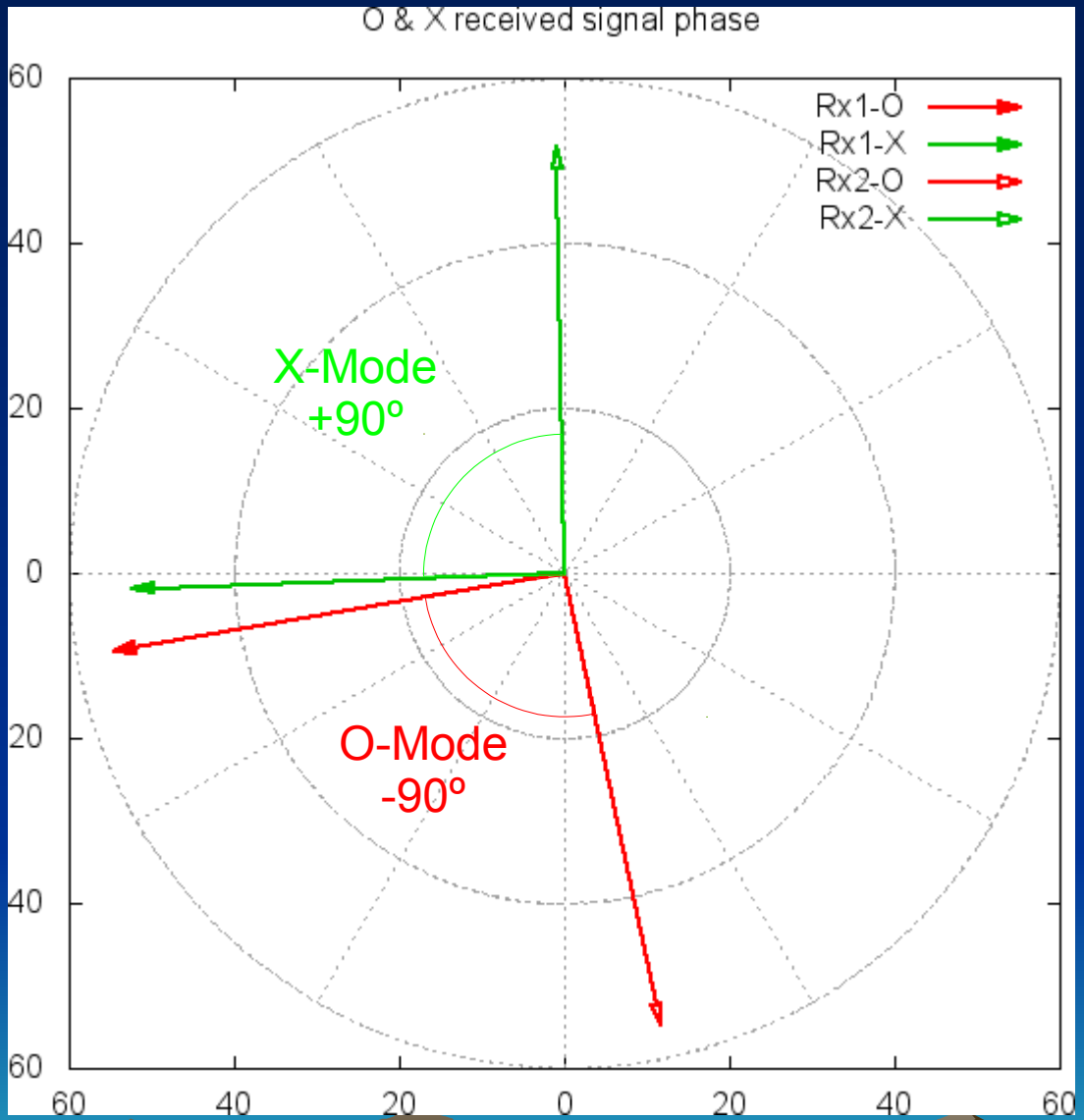
Dipoles: 25-35 dB SNR



10-15 dB SNR for ~3dB Cost

Boulder Ionosonde Station

Polarization Example: VIPIR



- Two orthogonal antennas
- Separate receivers
- O and X mode signals
- Range resolved
- Magnitude [dB]
- Phase [deg]
- -90 for O-mode
- +90 for X-mode
- Phase shift and sum
- Compare resulting amplitudes

SJJ18_20103081805O8.RIQ

San Juan Site Plan

- 10 VIPIR Rx Antennas
- 8 receivers
- 1 Digisonde Rx Loop antenna
- Aluminum towers
- Fiberglass rebar
- Long Term Facility
- Cat 3 Hurricane

Nominal ARL Site Plan

1” ~ 200 ft

Nominal Del Rio Site Plan

What We Have

- Ionosonde
  - Antennas and Towers
  - Signal Cables
  - Transmitter
  - Receiver
  - Data Analysis Computer
- Transmit License
- Expertise
- Documentation
- Construction Funding
- Future O&M funding presumed → Year-to-Year

Needs

Near Term

- Field Site
  - ~ 5 acres
  - Low RFI
- Host Agreement
- Construction
  - Permits
  - Concrete & Conduit
  - Tower Install
- Shelter
  - 10'x10', A/C
  - Power & Comm

Long Term

- Power and Internet
- Technical Support
  - 8 hrs/month
- Vegetation control
- Facilities Maintenance
  - A/C units
  - Corrosion
- Physical Security
  - Theft and Vandalism

Nominal Schedule

- Feb 2011 - Site Selection
- Apr 2011 – Agreements and Transmit License
- May 2011 – Construction Contract
- Jun 2011 – Instrument Refurbished
- Aug 2011 – Construction completed
- Sep 2011 – Instrument Installation
- Oct 2011 – Operations